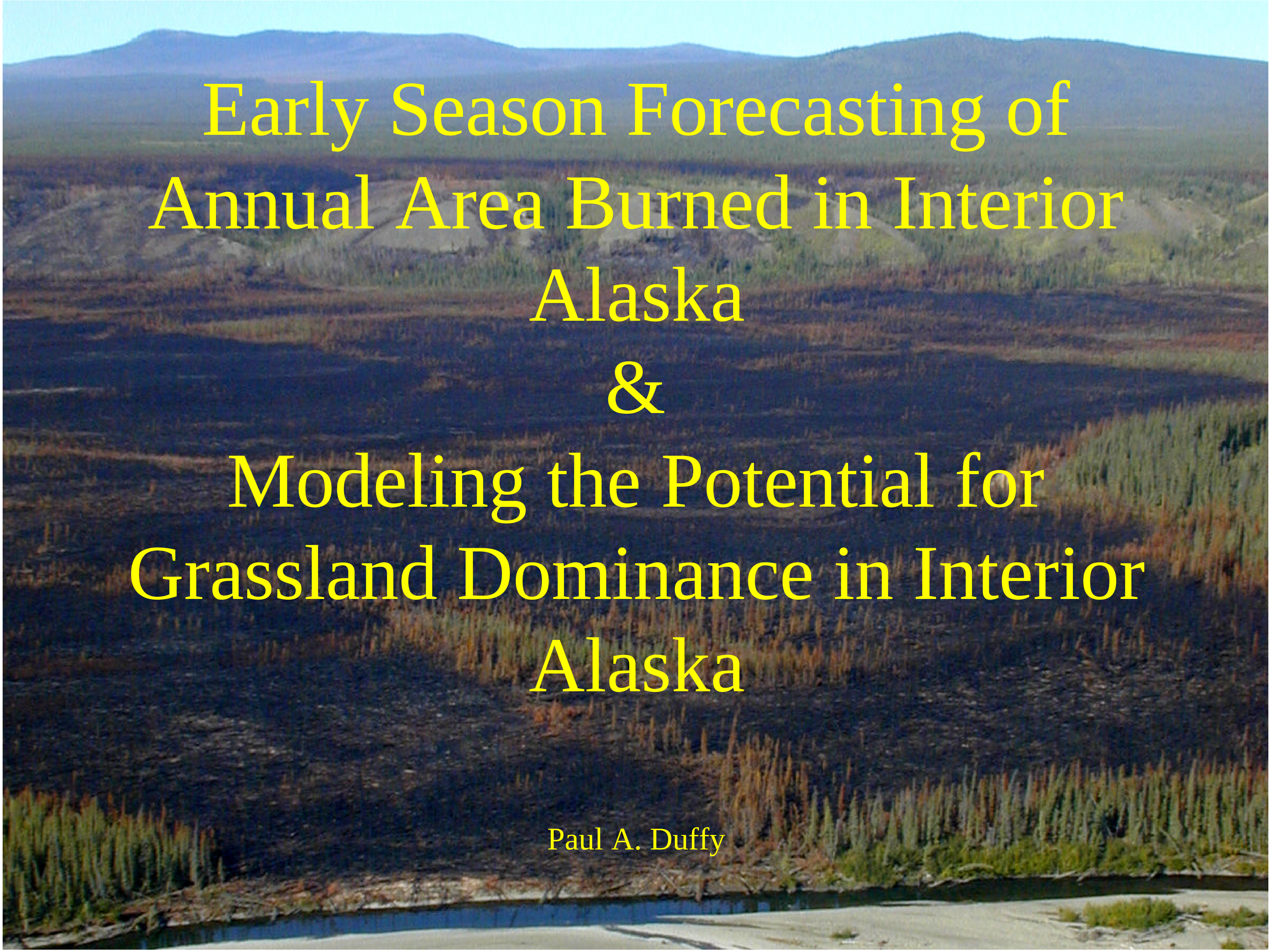
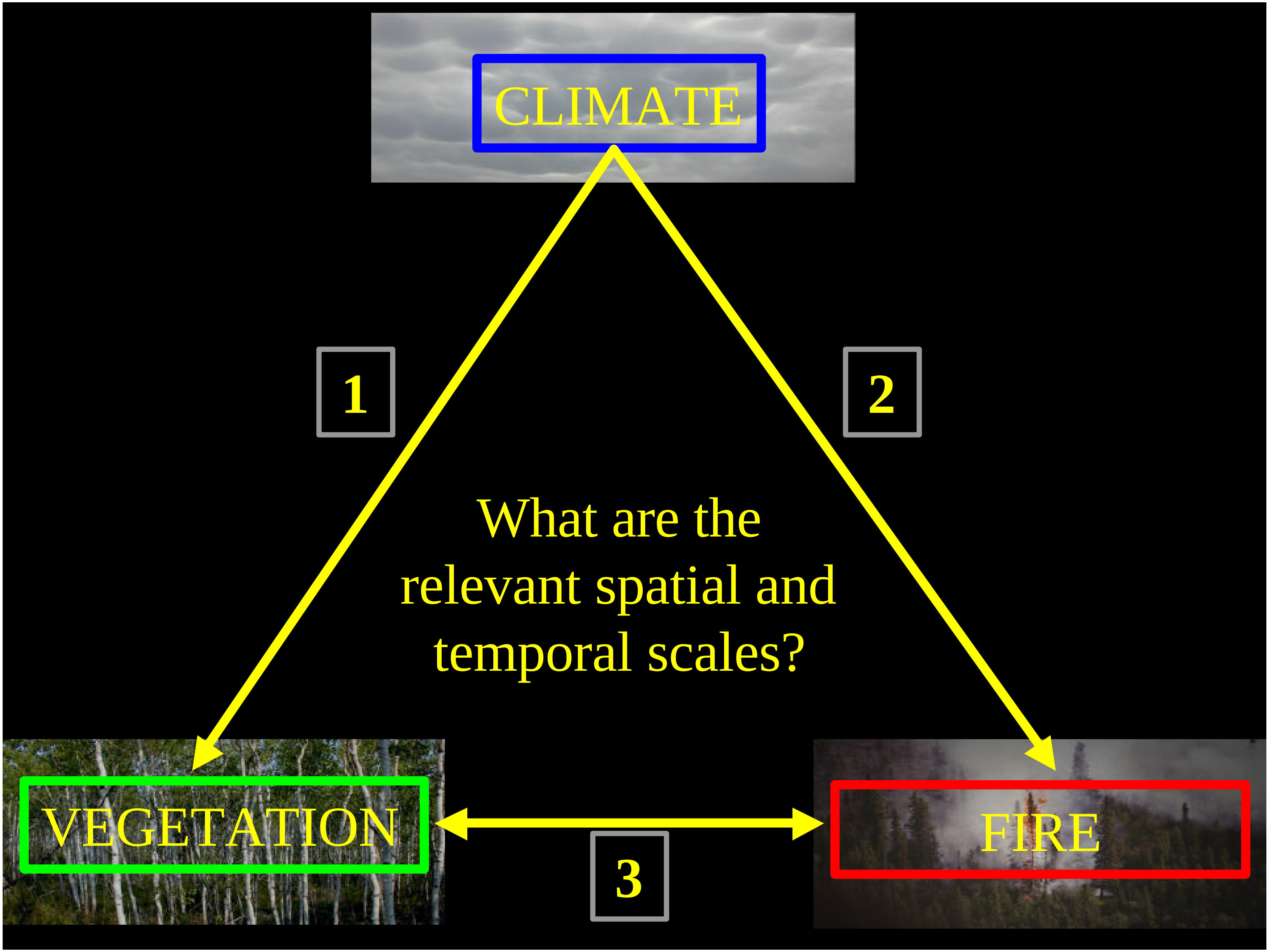


Early Season Forecasting of Annual Area Burned in Interior Alaska & Modeling the Potential for Grassland Dominance in Interior Alaska

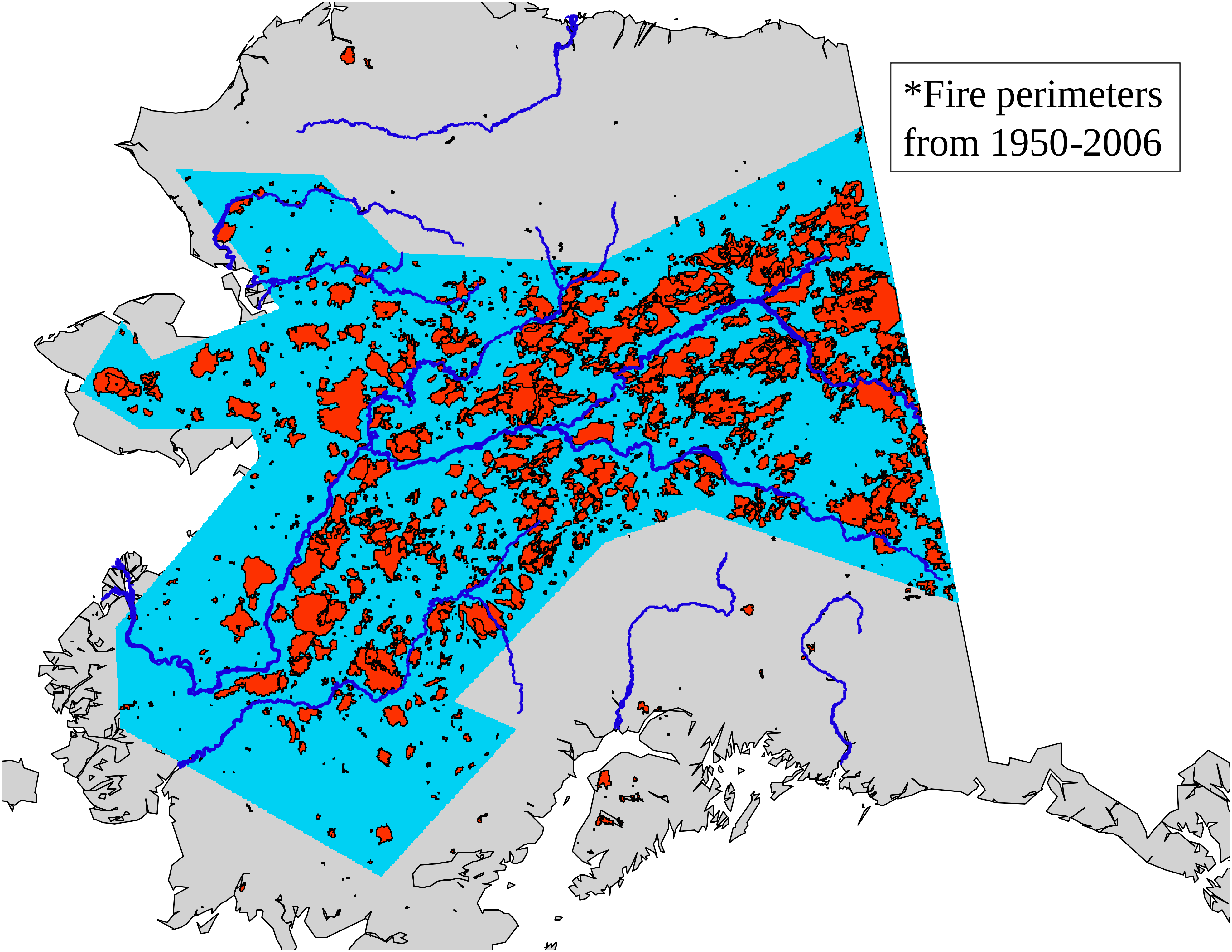
Paul A. Duffy


CLIMATE
1
2
What are the relevant spatial and temporal scales?
VEGETATION
3
FIRE

Obvious link between climate and fire

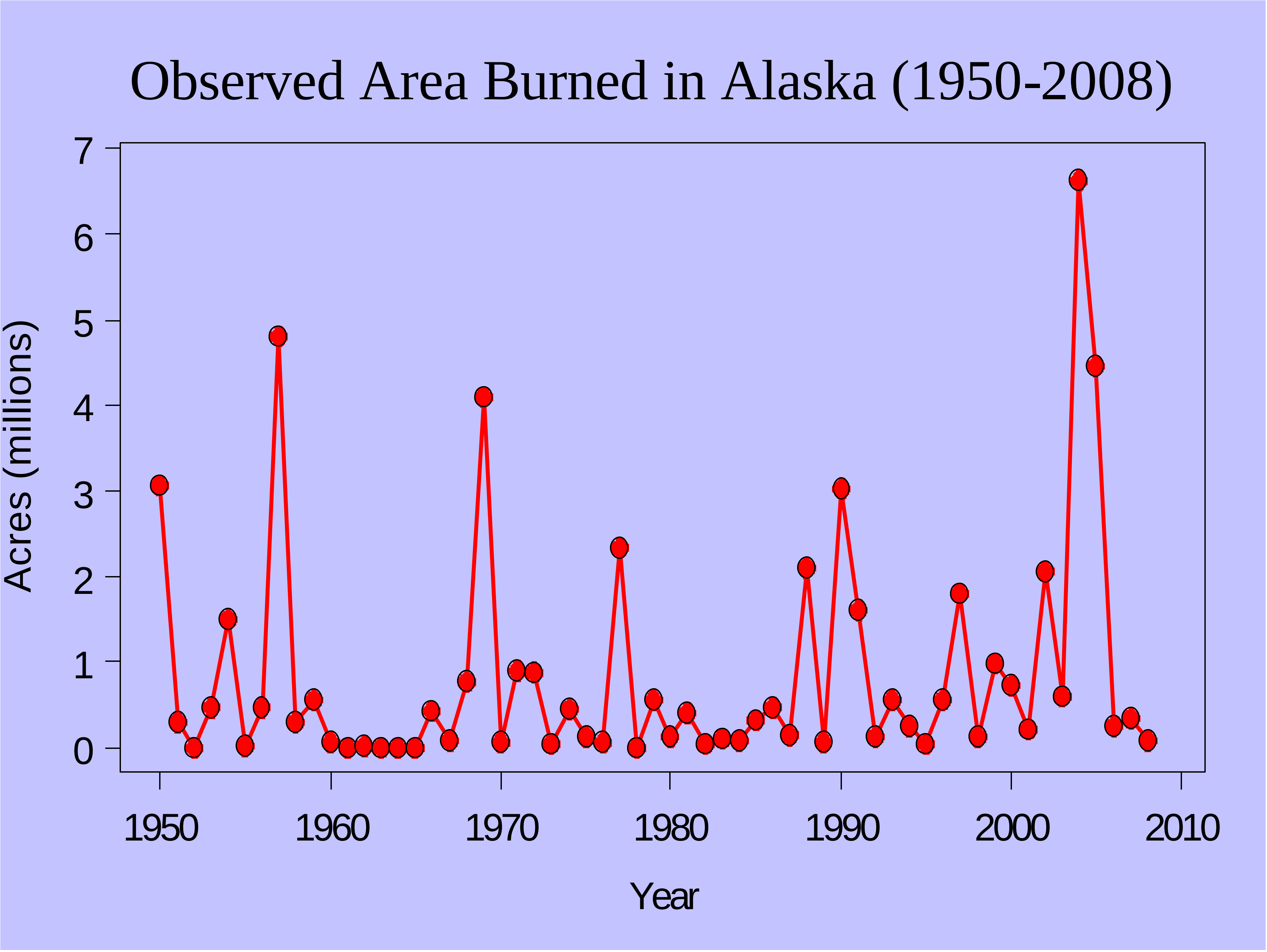
Spatial and temporal scales of interest…. not so obvious

2


*Fire perimeters
from 1950-2006

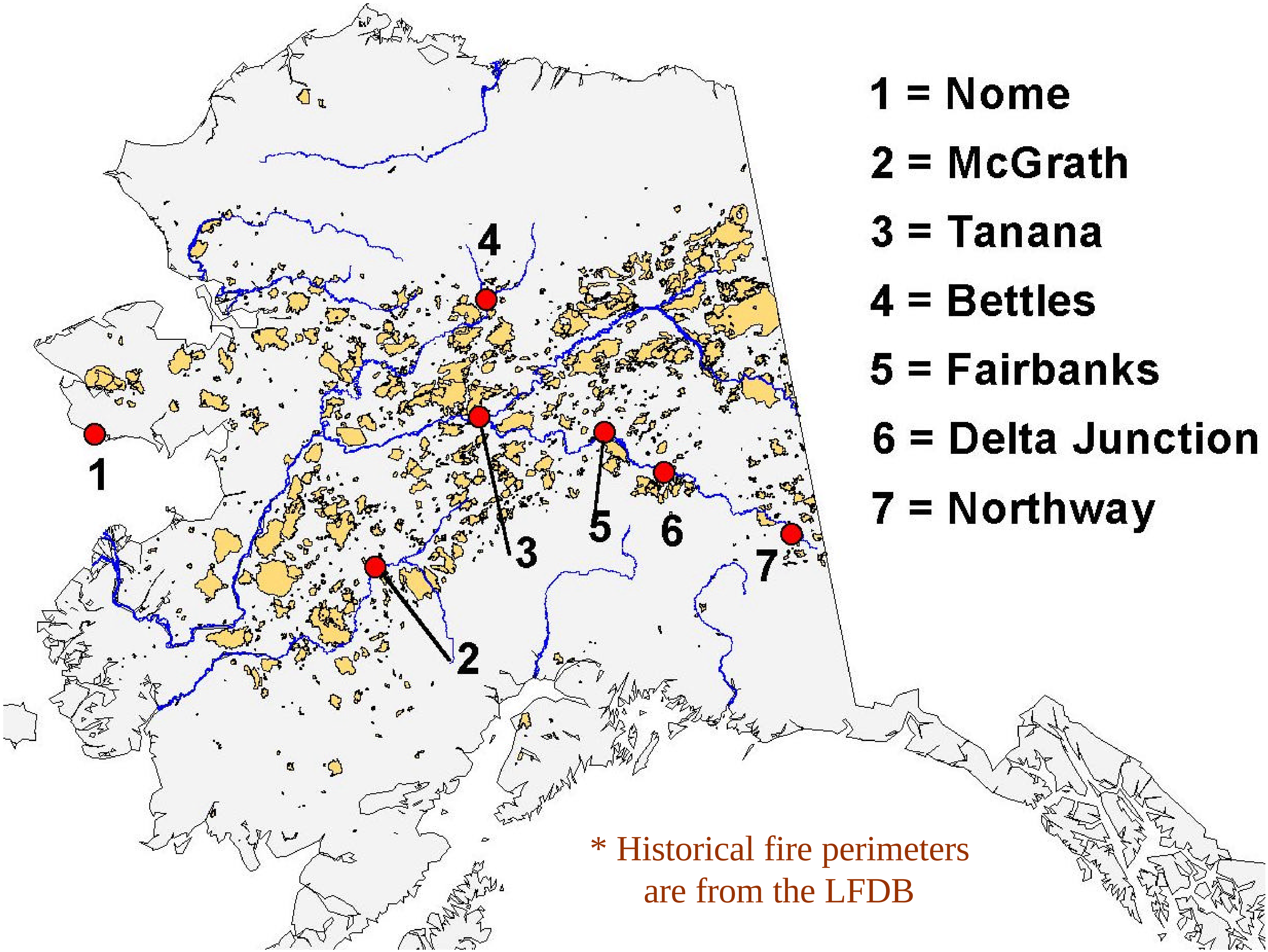
Statistical Model Development

- Response: Annual area burned
- Explanatory Variables:
  - Monthly temperature and precipitation
  - Monthly teleconnection indices


Observed Area Burned in Alaska (1950-2008)
Acres (millions)
0
1
2
3
4
5
6
7
1950
1960
1970
1980
1990
2000
2010
Year

Source of Climate Data

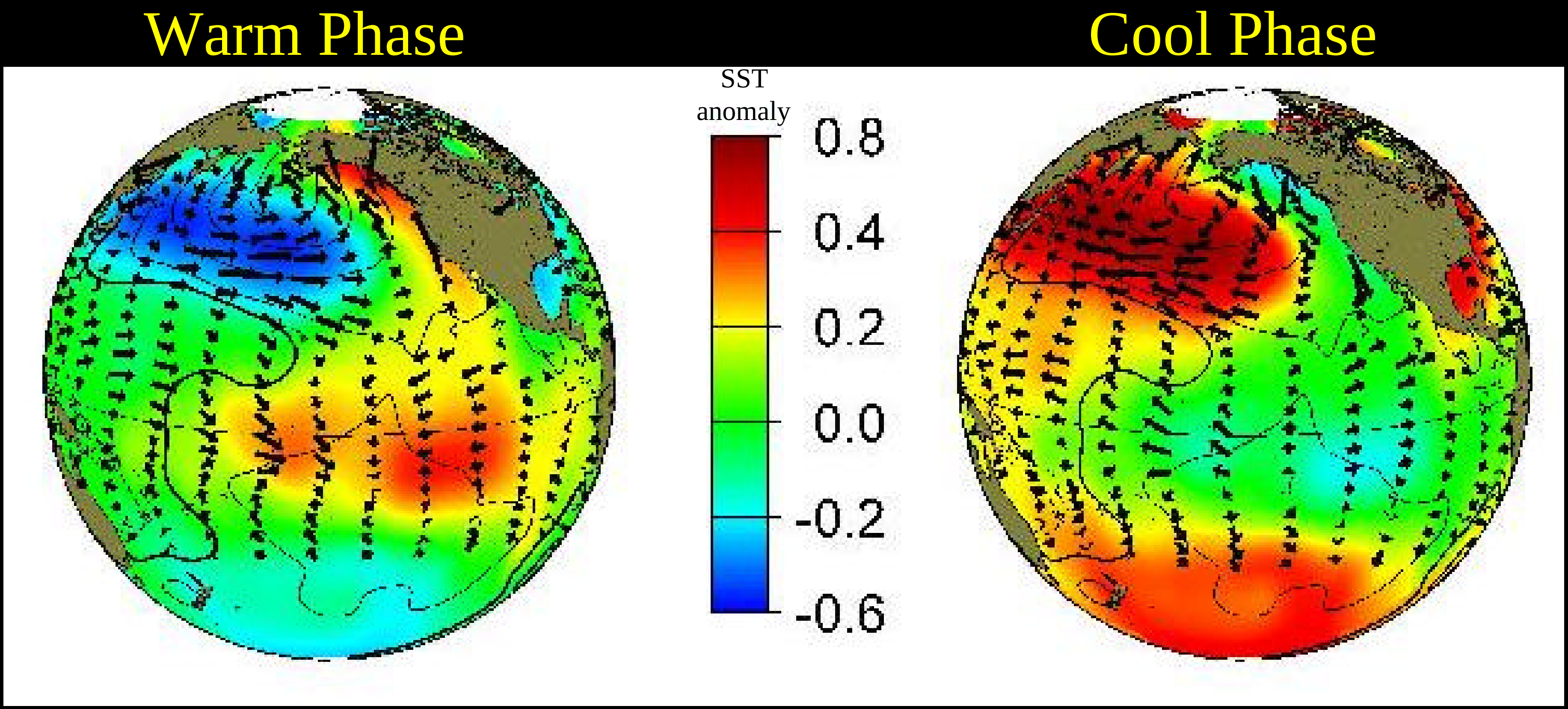
- Station data from across Alaska
- Only 7 stations with greater than 95% of the monthly temp and precip from 1950


1 = Nome
2 = McGrath
3 = Tanana
4 = Bettles
5 = Fairbanks
6 = Delta Junction
7 = Northway
1
2
3
4
5
6
7
* Historical fire perimeters are from the LFDB

Atmospheric Teleconnections

- ENSO is probably the most familiar
- Recurring and persistent shift in atmospheric circulation and/or sea surface temperatures

Pacific Decadal Oscillation



* Figure courtesy of Hare IPHC

Gradient Boosting Models

- Data-mining algorithm also used in machine-learning
- Binary recursive partitioning
- Minimize expected loss function over the function-space not parameter-space

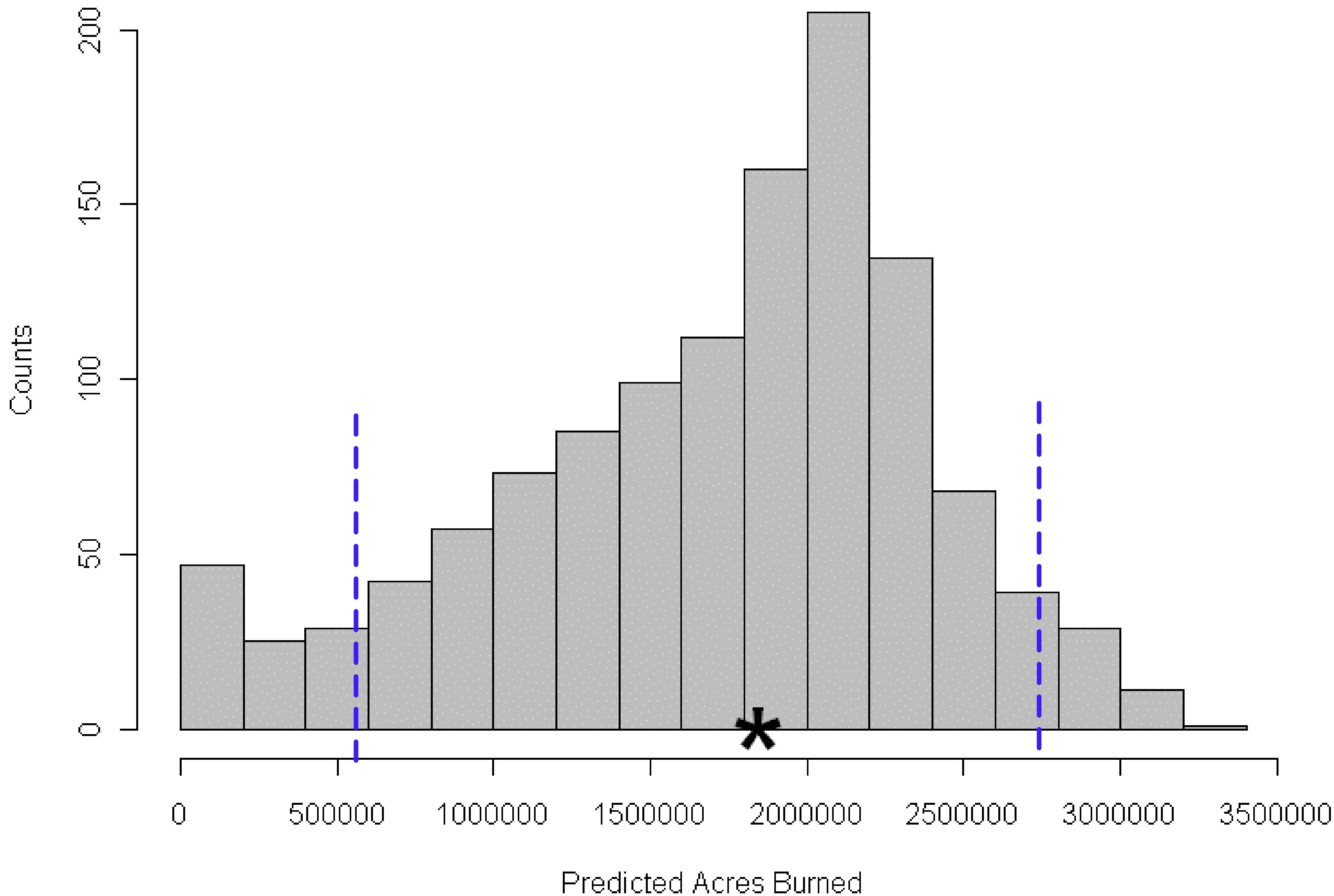
Issues with Forecasting

- Want to use part of the data to fit the model, and the other part to "test" it
- Can only use pre-season variables
- Need to quantify decision errors

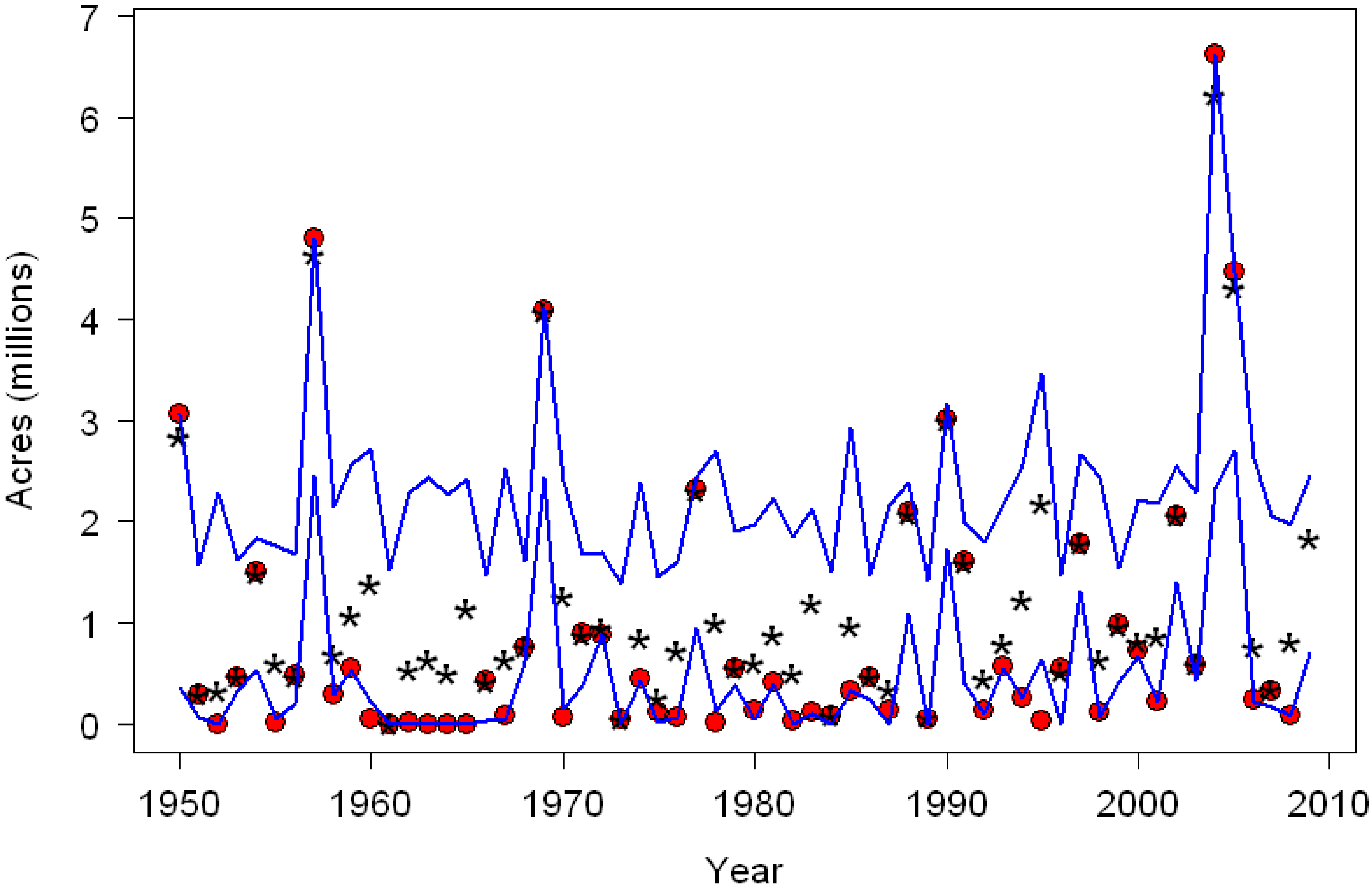
Experimental Approach

- Repeatedly pull out 10 years of data, fit the model, then predict at the 10 omitted years
- This is done 1000 times resulting in 1000 different models
- For each year, there is a distribution of predictions

Prediction(s) for the 2009 Season (May data)

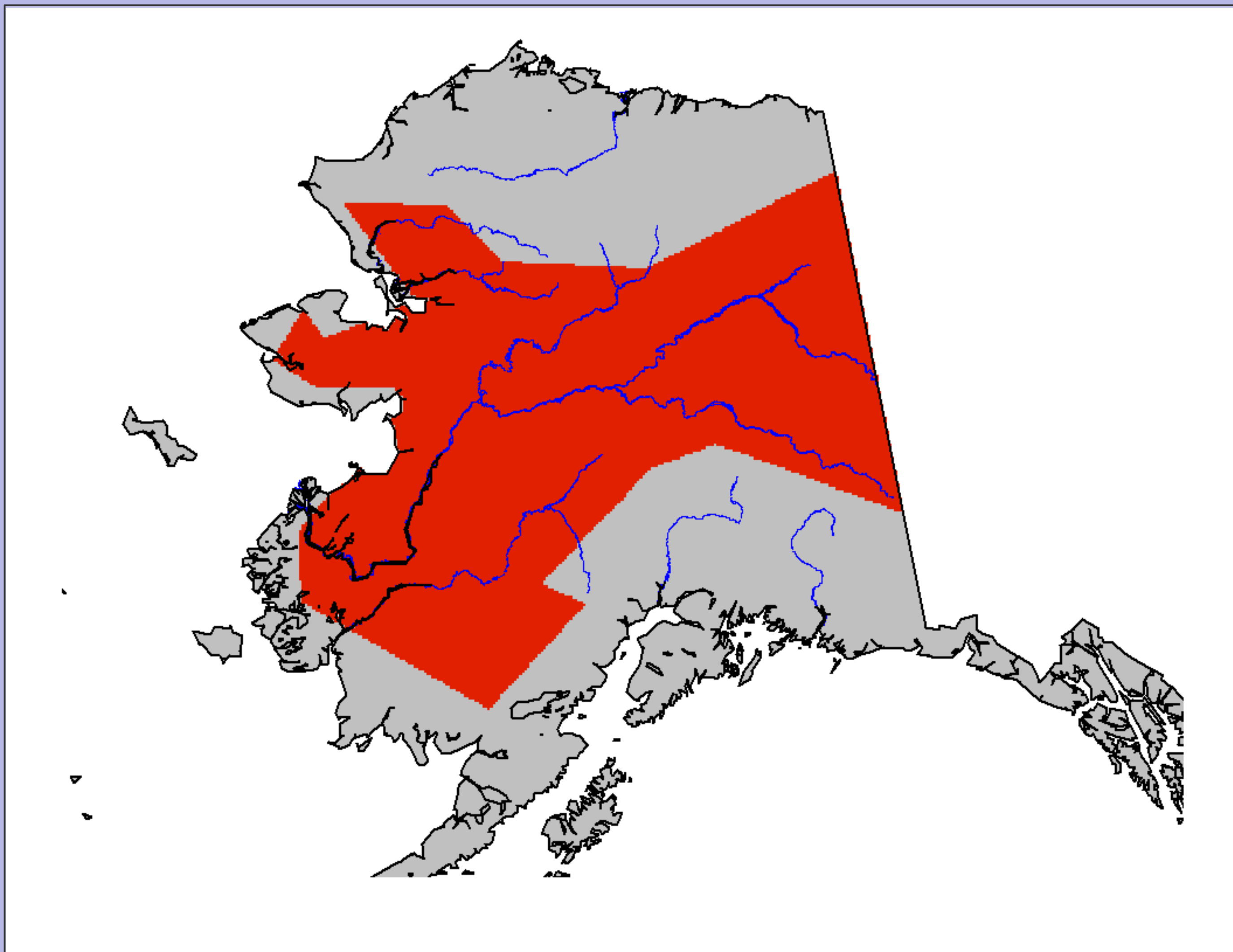


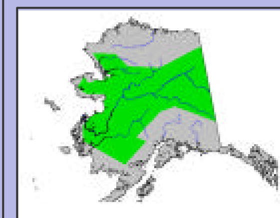
90% Uncertainty Intervals of Cross-Validated Predictions



*Cross-Validation performed by re-fitting the model 1000 times, each time eliminating 10 years of data

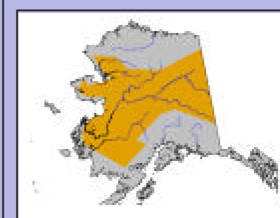
Forecast of Area Burned in 2009 Based on May Data





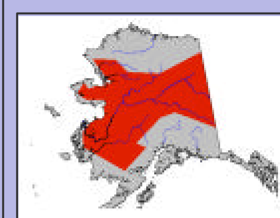
Low

< 500,000 acres



Mod

> 500,000 and
< 1.5 million acres

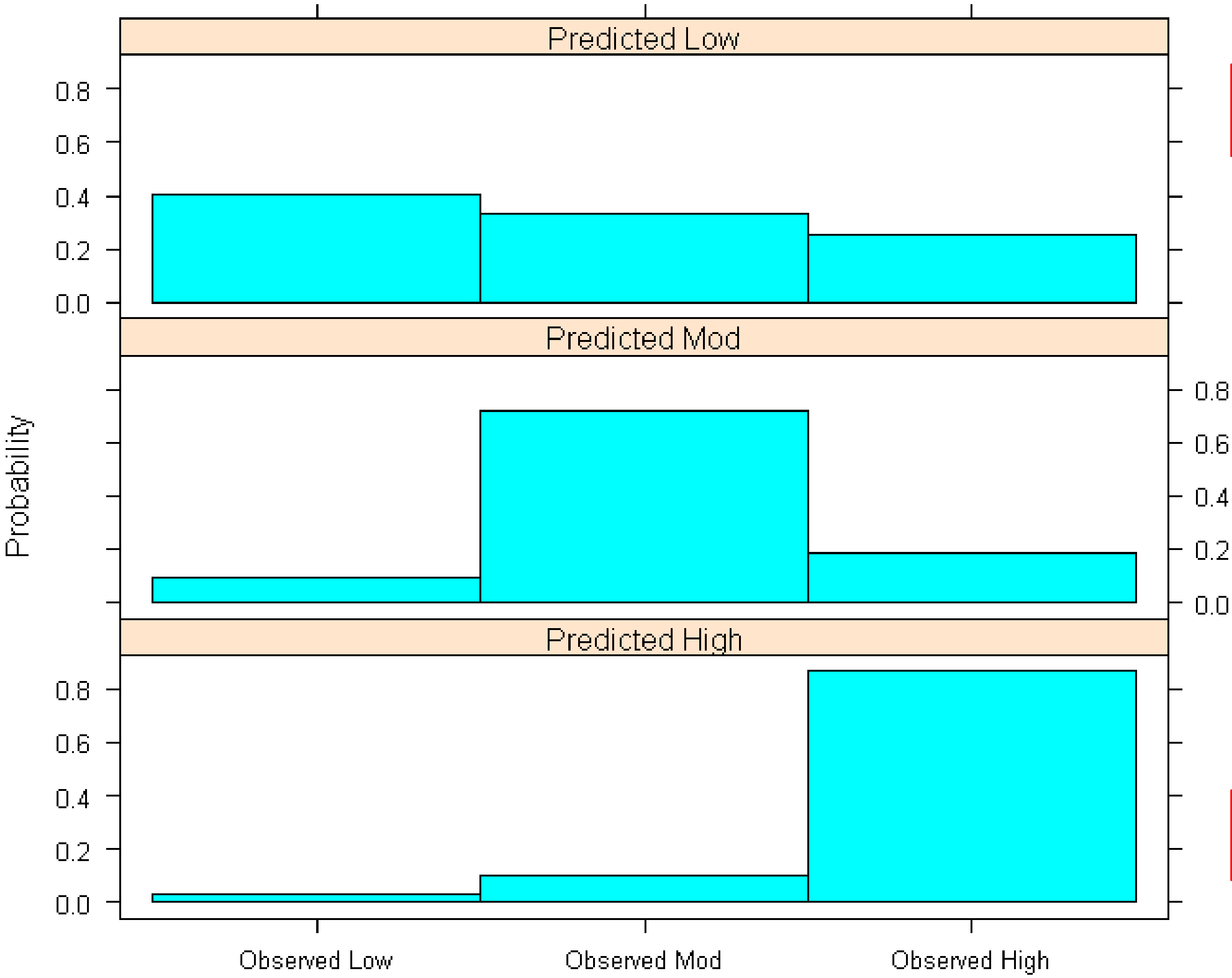


High

> 1.5 million acres

Median May forecast is 1,800,000 ac.

Error Table for Observed vs. Predicted

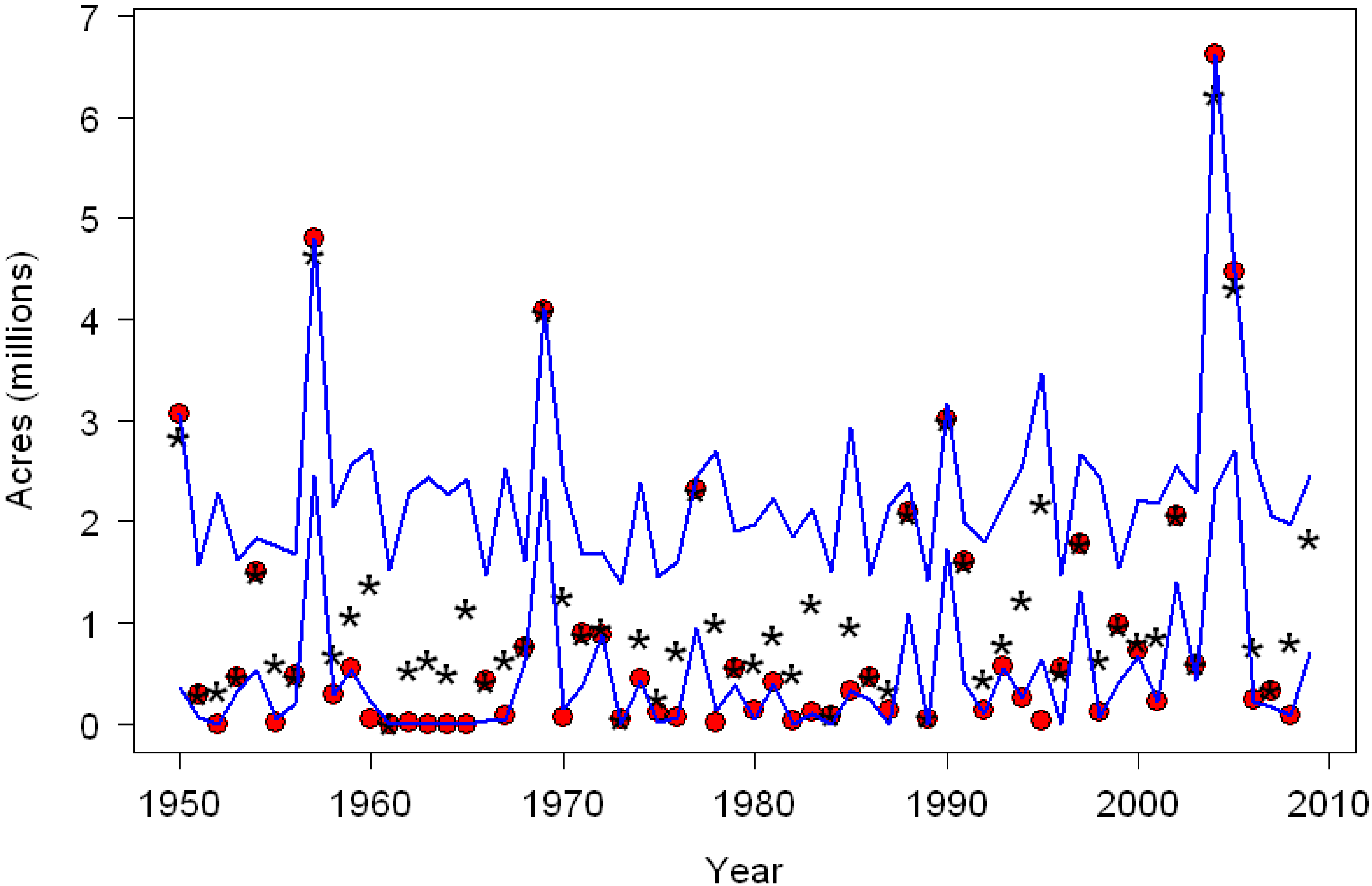


Small < 500,000

500,000 < Med < 1,500,000

Large > 1,500,000

90% Uncertainty Intervals of Cross-Validated Predictions



*Cross-Validation performed by re-fitting the model 1000 times, each time eliminating 10 years of data

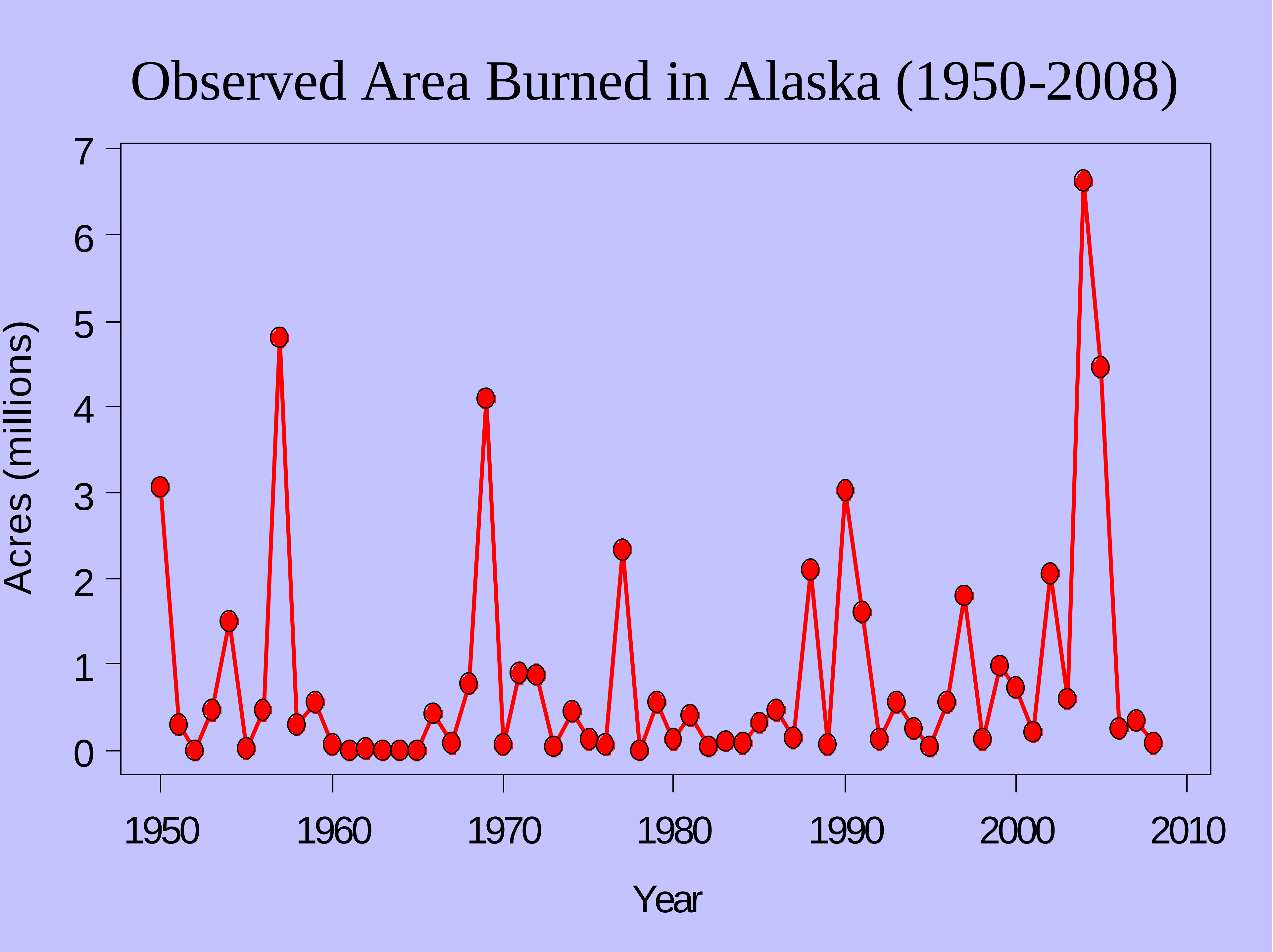
Evolution of Forecasts

- Median March forecast was 336,000 ac.
- Median April forecast was 595,000 ac.
- Median May forecast was 1,800,000 ac.

- March Model:
  - Polar (Jan, Feb avg)
  - East Pacific/North Pacific (Jan, Feb difference)
  - Pacific North American (Jan)
  - West Pacific (Jan)

- April Model:
  - Polar (Jan, Feb avg)
  - East Pacific/North Pacific (Feb, Apr difference)
  - Pacific North American (Jan)
  - **April Precip**

- May Model:
  - Polar (Jan, Feb avg)
  - East Pacific/North Pacific (**January and May** average)
  - Pacific/North American (**May**)
  - **Average May Temperature**

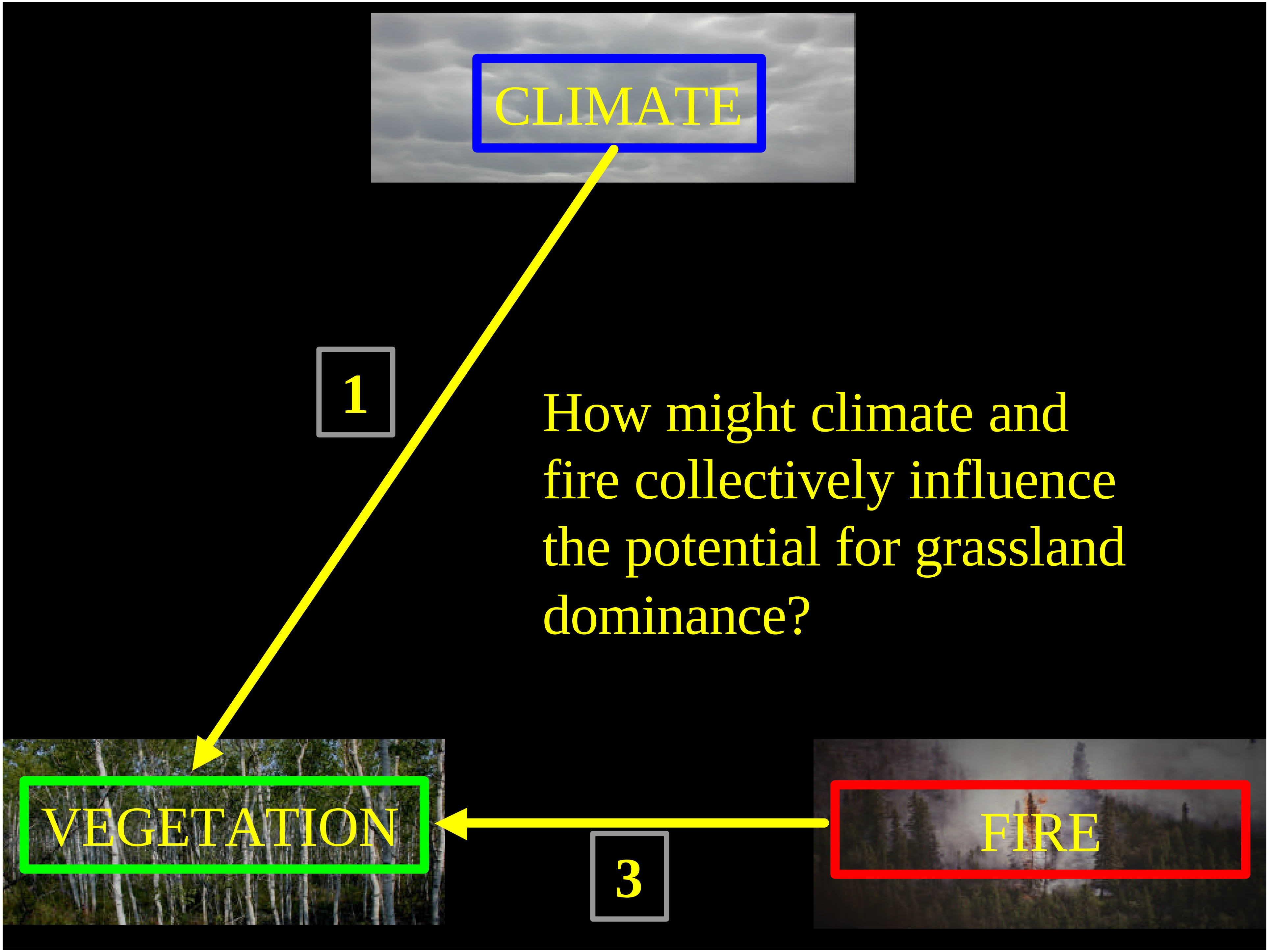

Observed Area Burned in Alaska (1950-2008)
Acres (millions)
0
1
2
3
4
5
6
7
1950
1960
1970
1980
1990
2000
2010
Year

How is this useful?

- Need feedback from managers to better characterize how this information might be used in early season decision making
- Part of this is accurately conveying the level of uncertainty associated with the forecasts
- This might be used to proactively identify analysts that are called up after PL3

Next Steps

- Quantify the uncertainty associated with the development of forecast through the early season
- Determine if this is a useful tool for the community


CLIMATE
1
How might climate and fire collectively influence the potential for grassland dominance?
VEGETATION
3
FIRE

Goal

- Estimate the disturbance regime and environmental conditions that would result in dominance of grassland at roughly 1 km^2 spatial resolution.

Methods

- Use the available literature to develop a conceptual model
- Examine the paleorecord for times when grasslands were more prevalent in interior Alaska
- Estimate probabilities for transitions among states within the ALFRESCO modeling framework

Example: *Calamagrostis canadensis*

- “Up to 1m tall, culms from creeping rhizomes forming tussocks...”
- “Meadows, wet places. Common in interior”

- Hulten 2000

Ecology of CC

- Common colonizer after disturbance
- Colonization from seed if disturbance is near moist areas
- Can gain dominance from vegetative growth (rhizomatous) if fire is low severity

Literature Review

- A fair bit of research on CC is focused on impacts on forest regeneration after logging
- Significant impact on aspen regeneration and spruce seeding survival have been shown

Literature Review

- Strength of CC population is a function of time since disturbance
- Prolific flowering is typically only observed in marshy areas and recently disturbed sites

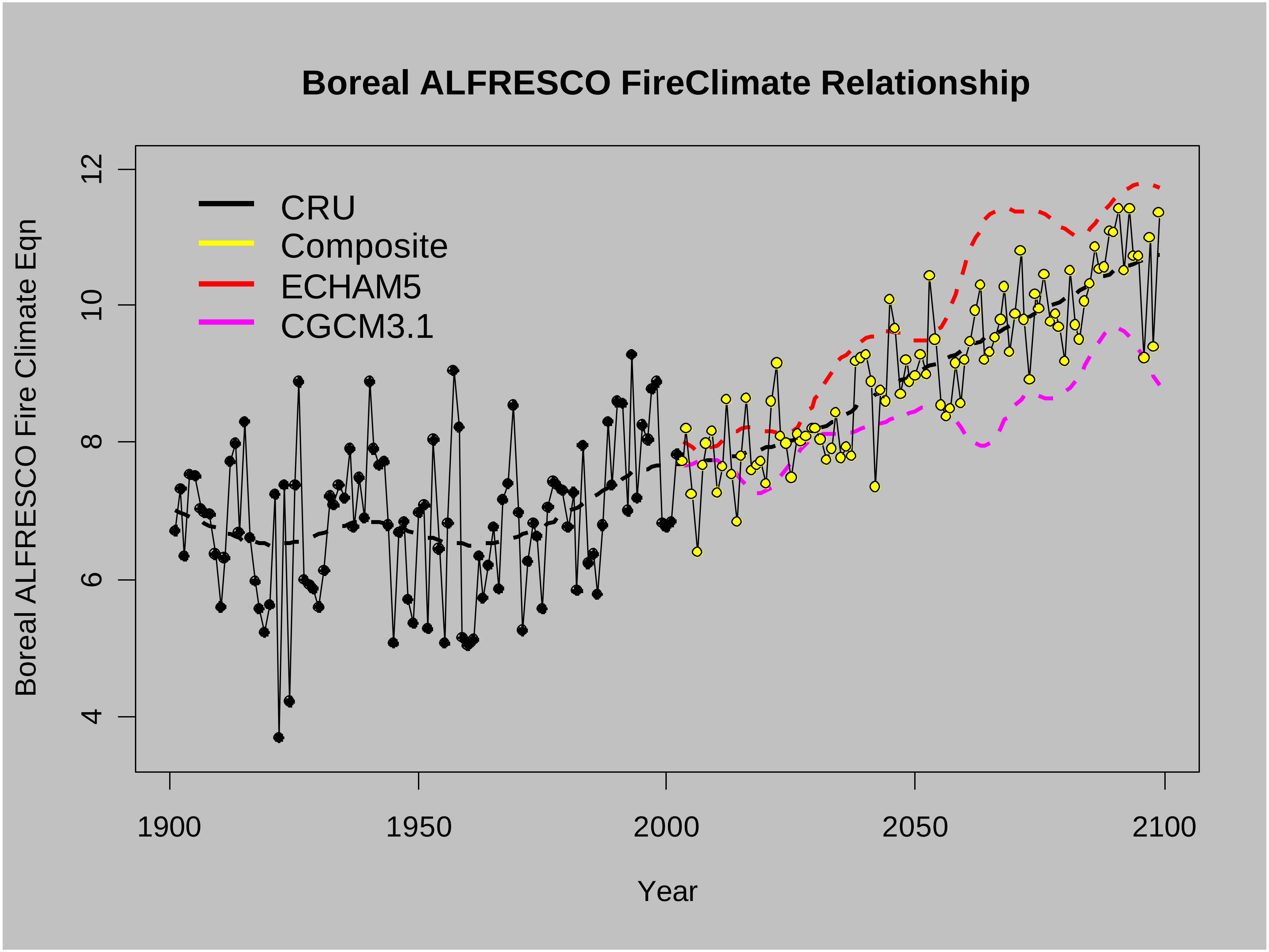
Paleorecord: Preliminary Summary

- Vegetation changes were driven by changes in both temperature and precipitation

- Responses of forest tree species provide information about likely scenarios in response to future warming (e.g. Picea will likely not respond favorably to warmer and drier temperatures)

Future Climate and Disturbance

- IPCC future climate scenarios indicate warmer and drier future
- ALFRESCO modeling suggests increased disturbance from fire

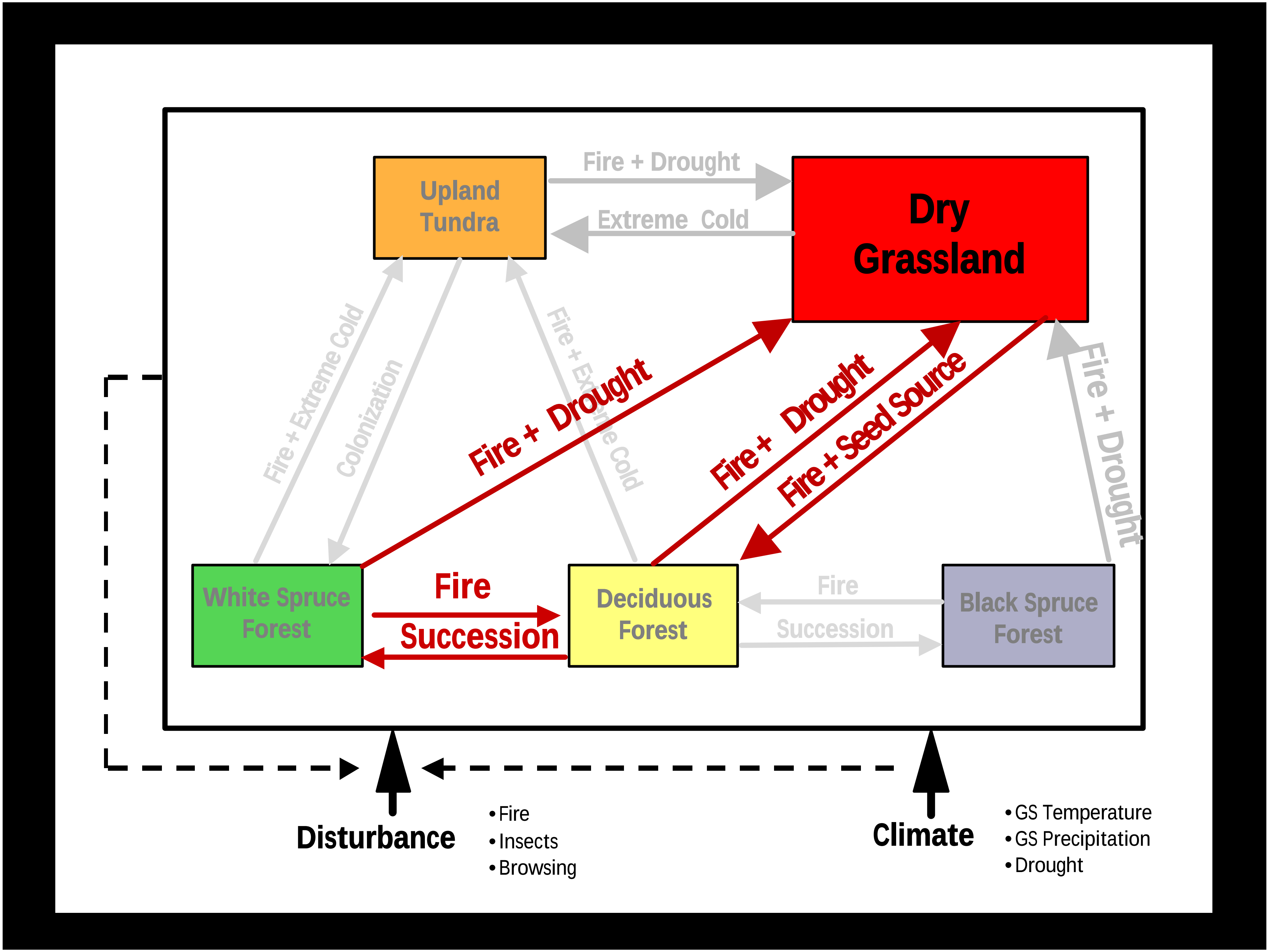

Boreal ALFRESCO FireClimate Relationship
CRU
Composite
ECHAM5
CGCM3.1
Boreal ALFRESCO Fire Climate Eqn
4
6
8
10
12
1900
1950
2000
2050
2100
Year

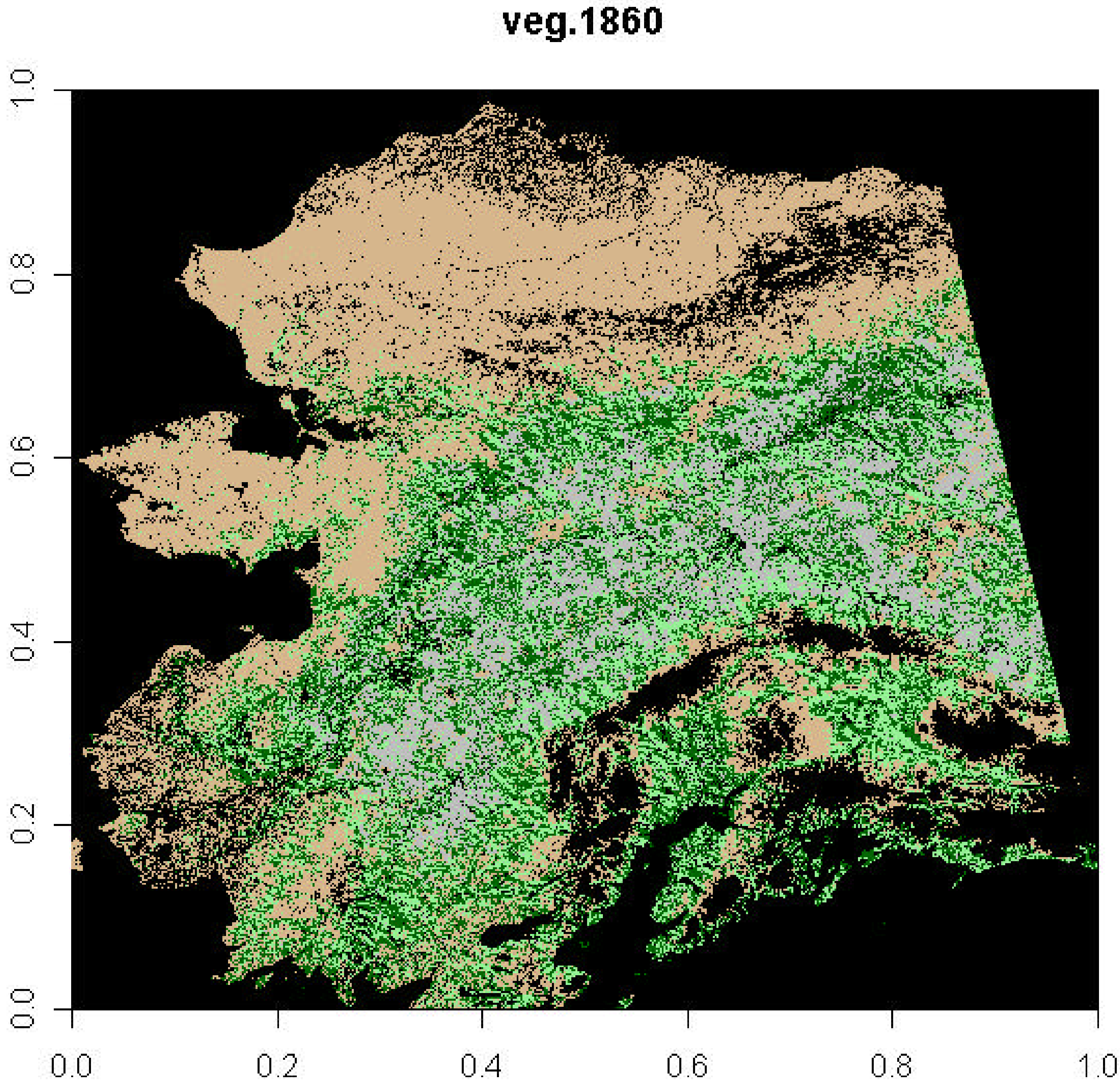
Future Climate and Disturbance

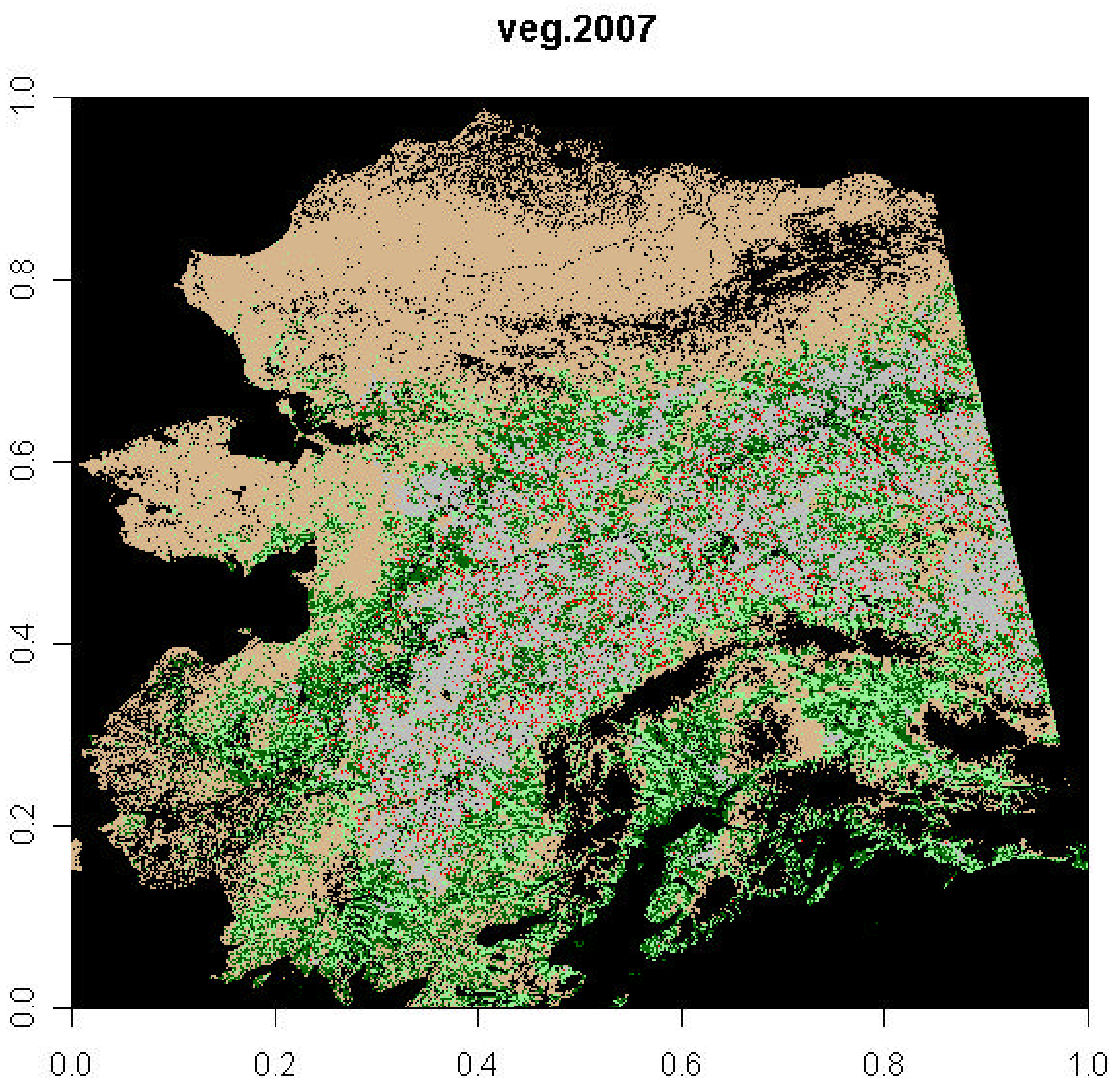
- Precipitation is highly uncertain, yet critically important
- Even if there are no “trends” in precipitation that occur in the future, changes in the interannual variability of precipitation may significantly impact post-fire succession

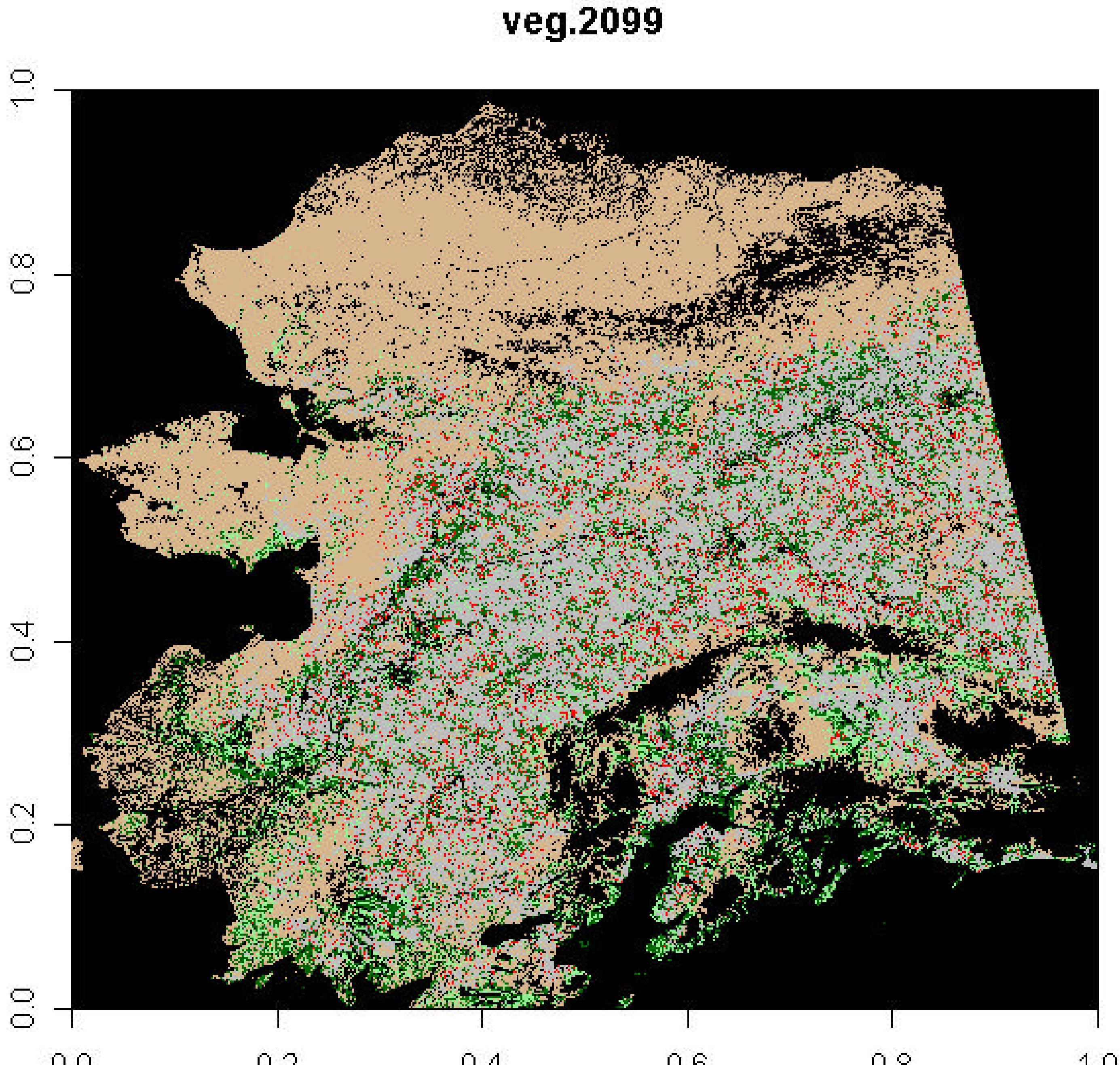
Conceptual Model

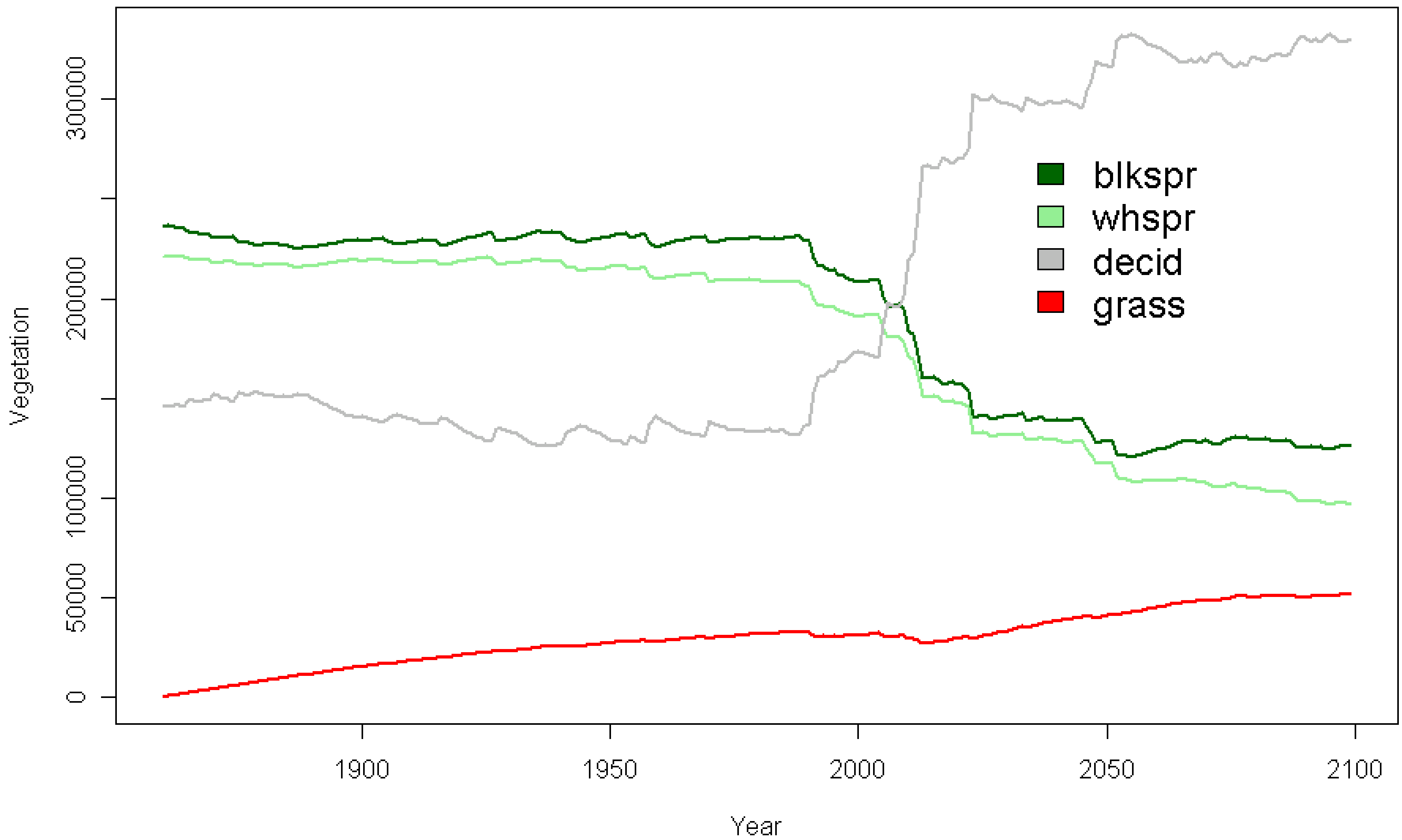
- In high severity burns, availability of seed source for grasses and weather in following years will play a strong role
- In low/moderate severity burns where grass is already present, grass will be a strong competitor


Upland Tundra
Fire + Drought
Extreme Cold
Dry Grassland
Fire + Extreme Cold
Colonization
Fire + Extreme Cold
Fire + Drought
Fire + Drought
Fire + Seed Source
Fire + Drought
White Spruce Forest
Fire
Succession
Deciduous Forest
Fire
Succession
Black Spruce Forest
Disturbance
• Fire
• Insects
• Browsing
Climate
• GS Temperature
• GS Precipitation
• Drought


veg.1860
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0


veg.2007
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


veg.2099
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0


blkspr
whspr
decid
grass
Vegetation
0
50000
100000
200000
300000
1900
1950
2000
2050
2100
Year

Initial Implementation

- Only dealing with the white spruce vegetation type (i.e. warmer drier, S facing)
- In high severity burns, availability of seed source for grasses and weather in following years will play a strong role
- In low/moderate severity burns where grass is already present, grass will be a strong competitor

Iterative Data Assimilation in the Modeling Framework

- Validate model output using field data
- Part of the Fish Creek fire came back as CC and reburned in the Rex Creek fire this year
- This would be an excellent place to explore…
  - Pre-fire veg for Fish Creek
  - Burn severity
  - Post fire weather for subsequent years

Acknowledgements

- Alaska Center for Climate Assessment and Policy

- Scenarios Network for Alaska Planning